Electrodynamic Dust Shield Demonstrator

Charles G. Stankie

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Charles G. Stankie[1]
University of Central Florida, Orlando, Florida, 32816

The objective of the project was to design and manufacture a device to demonstrate a new technology developed by NASA's Electrostatics and Surface Physics Laboratory. The technology itself is a system which uses magnetic principles to remove regolith dust from its surface. This project was to create an enclosure that will be used to demonstrate the effectiveness of the invention to The Office of the Chief Technologist.

Nomenclature

EDS = electrodynamic dust shield
ESPL = Electrostatics and Surface Physics Laboratory
ITO = indium tin oxide

I. Introduction

ONE of the most important challenges of space exploration is actually caused by something very small and seemingly insignificant. Dust in space, most notably on the moon and Mars, has caused many unforeseen issues. Dirt and dust on Earth, while a nuisance, can be easily cleaned and kept at bay. However, there is considerably less weathering and erosion in space. As a result, the microscopic particles are extremely rough and abrasive. They are also electrostatically charged, so they cling to everything they make contact with. This was first noted to be a major problem during the Apollo missions. Dust would stick to the spacesuits, and could not be wiped off as predicted. Dust was brought back into the spacecraft, and was even inhaled by astronauts. This is a major health hazard. Atmospheric storms and other events can also cause dust to coat surfaces of spacecraft. This can cause abrasive damage to the craft. The coating can also reduce the effectiveness of thermal insulation and solar panels.[1] A group of engineers at Kennedy Space Center's Electrostatics and Surface Physics Laboratory have developed a new technology, called the Electrodynamic Dust Shield, to help alleviate these problems. It is based off of the electric curtain concept developed at NASA in 1967. "The EDS is an active dust mitigation technology that uses traveling electric fields to transport electrostatically charged dust particles along surfaces. To generate the traveling electric fields, the EDS consists of a multilayer dielectric coating with an embedded thin electrode grid running a multiphase low frequency AC signal. Electrostatically charged particles, such as those encountered on the moon, Mars, or an asteroid, are carried along by the traveling field due to the action of Coulomb and dielectrophoretic forces."[2] The technical details have been described in a separate article. This document details the design and construction process of a small demonstration unit. Once finished, this device will go to the Office of the Chief Technologist at NASA headquarters, where it will be used to familiarize the public with the technology.

[1] NASA KSC FO Intern, Prototype Development Laboratory, Kennedy Space Center, University of Central Florida

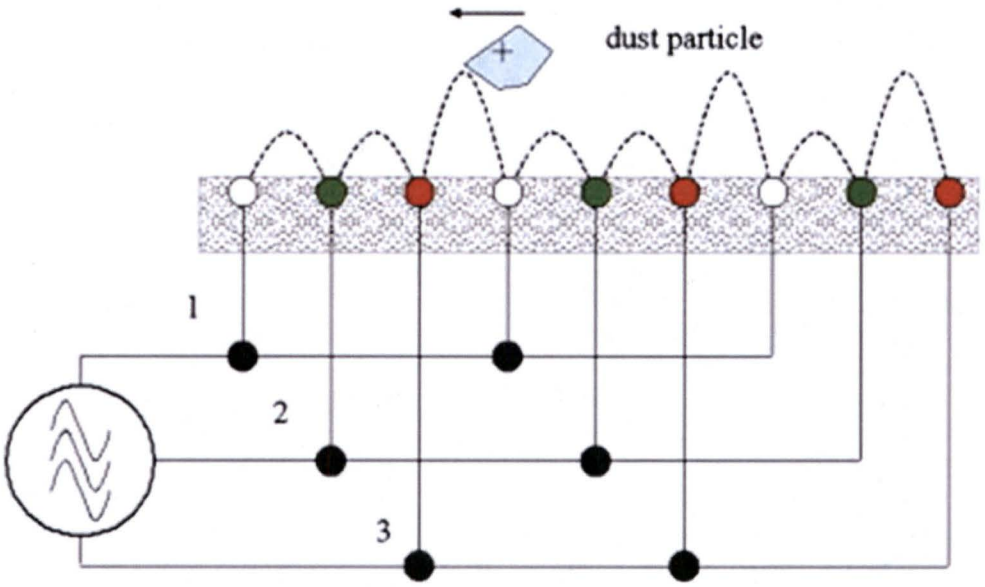

Figure 1. A Three-phase electric curtain. [Courtesy of NASA]

Figure 2. Lunar dust has electrostatic charge, which contributes to its ability to cling to everything. As seen in these Apollo mission pictures of Gene Cernan covered in lunar dust. [Courtesy of NASA]

II. Initial Design

This is an evolving technology, with ongoing research and development at the ESPL. The ESPL has a few small experimental EDS units. However, they are prototypes which are not designed to be very user friendly or have a polished aesthetic design. One of the old units was dissected in order to help understand the components inside, and how they needed to connect and fit together. A new chassis was constructed with aluminum sheet metal, which may be powder coated in the future. It was designed for ease of manufacturing, utilizing a minimum amount of resources. All of the panels will be cut out using a water-jet, with almost no post machining. Complicated parts were designed to be created with 3d printing, drastically reducing time and cost of production without sacrificing quality or visual appeal.

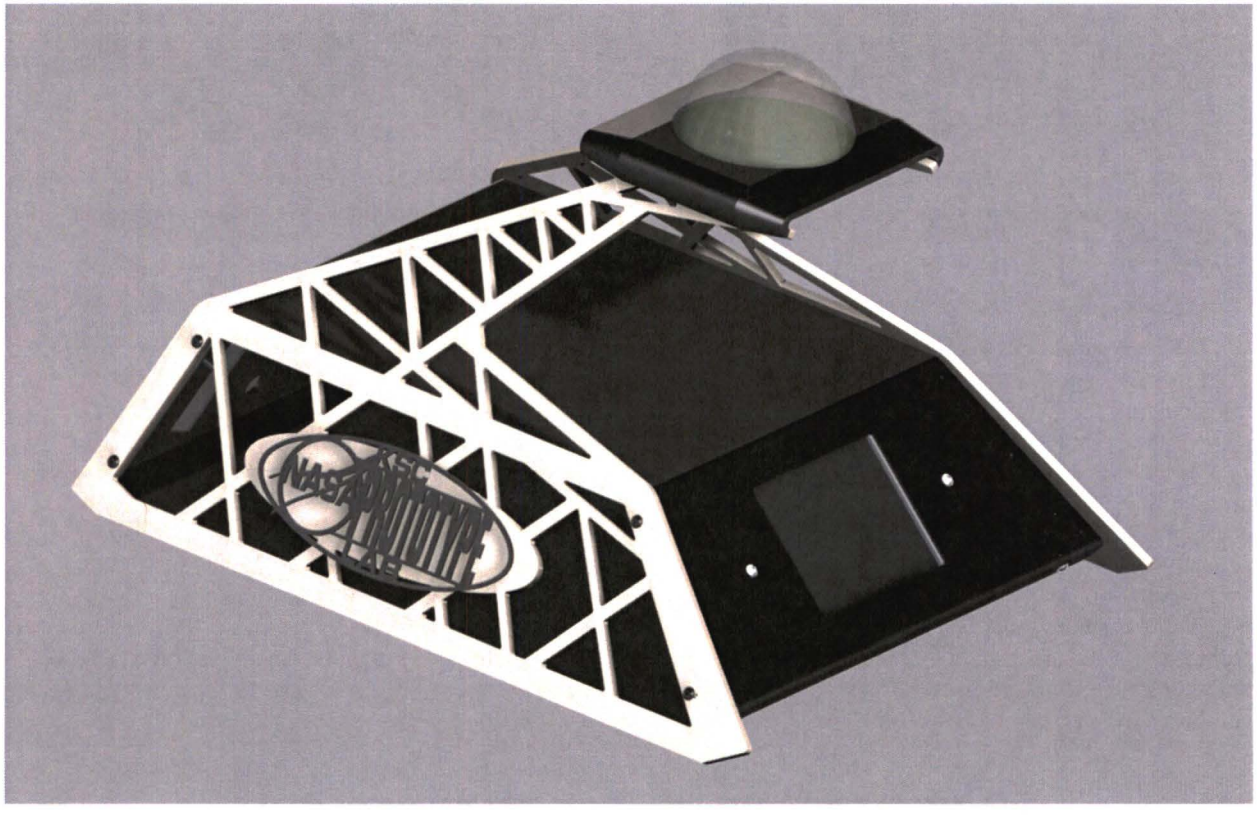

Figure 3. Render of one of the demonstrator concepts.

III. User Interface

The original test units were very bare, yet still had complicated controls. This demonstrator needed a new and easy to understand interface. The dangerous high voltage equipment was designed to be concealed entirely within the chassis of the unit. All of the controls were moved onto a custom touchscreen display. The touchscreen also opened the possibility for displaying more information than a simple on/off switch. While the interface is still currently in development, it will be far more user friendly.

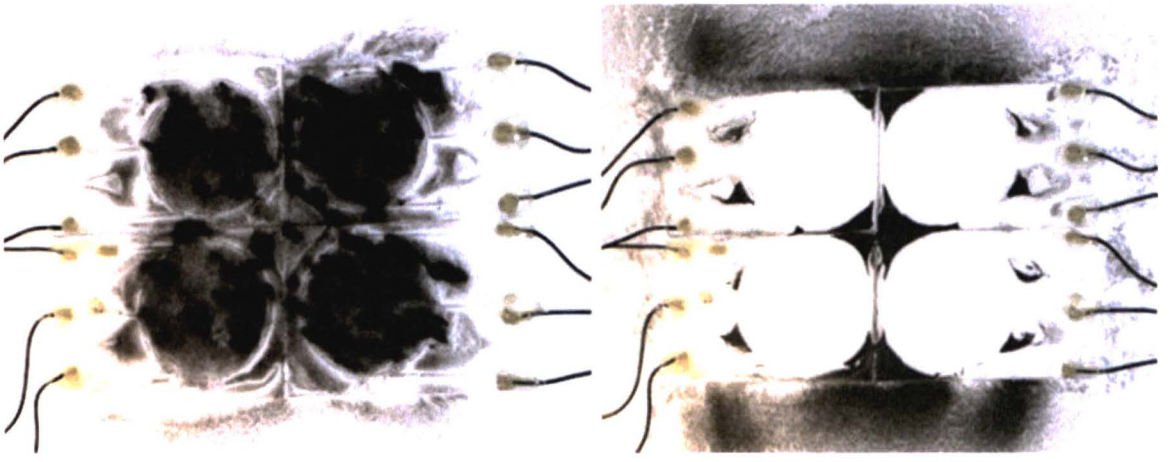

Figure 4. Testing of transparent EDS with ITO electrodes at vacuum with simulated lunar dust. [Courtesy of NASA]

IV. Dust Display Bed

The centerpiece of the unit is the shield itself, and its performance. While the design is not entirely finalized, it has gone through a few iterations. The device has a sealed container, which has a preloaded amount of dust that mimics regolith. While the prototypes had an open design, and dust could be added as needed, this new unit had to recycle the particles. The ESPL developed a dust shield with two separate spiral electrode circuits. Energizing the first circuit throws dust off of it outwards, and onto another concentric circuit. When this second circuit is turned on, it throws that same dust back in to its initial position. While the systems works even better than expected, a coating on the shield has begun to wear off and cause problems over time. The final version will have circuits printed onto a different type of material, which should resolve the issue. The actual enclosure for the dust is a transparent dome. It will either be made out of acrylic or polycarbonate. Significant testing remains to determine if dust will get stuck to the inside walls of the enclosure, reducing visibility. Parameters that have not been finalized include the dimensions of the dome, and the size of the mounting plate. This mounting plate will also be used to help corral the dust and prevent it from touching the walls of the dome. The ESPL has also begun to consider coatings that may help with this problem.

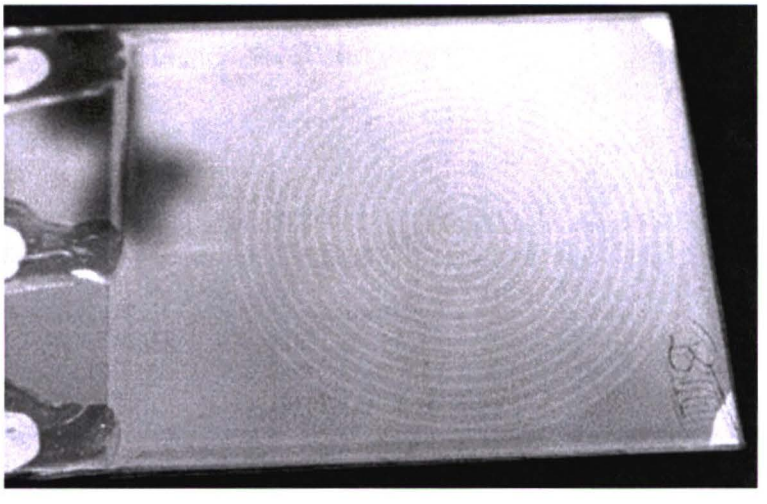

Figure 5. Three-phase transparent dust shield with a spiral configuration. [Courtesy of NASA]

V. Conclusion

At the date of this publication, the electrodynamic dust shield demonstrator is a work in progress. The chassis and electronics are finalized, but some smaller technical details still need to be worked out. During the coming weeks, the dust enclosure will be tweaked and tested before being put into final manufacture. All of this extra effort will lead to a polished product that will continue to demonstrate this powerful technology for years to come, and the lessons learned will be applied to future space exploration technology.

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